R FOR DATA SCIENCE

Research Methods in Psychology I & II ▪ Department of Psychology ▪ Colorado State University

BY THE END OF THIS INTRODUCTION YOU WILL:

1. Be familiar with the field of Data Science.
2. Have R and RStudio successfully loaded on your laptop.
3. Know a bit about the key features of R Studio.

A FEW R RESOURCES:

R Bloggers:
https://www.r-bloggers.com/

Stack Overflow (community):
https://stackoverflow.com/

R for Data Science:
http://r4ds.had.co.nz/

Quick R:
http://www.statmethods.net/

ATS UCLA stat examples:
https://stats.idre.ucla.edu/other/dae/

R Documentation
https://www.rdocumentation.org/

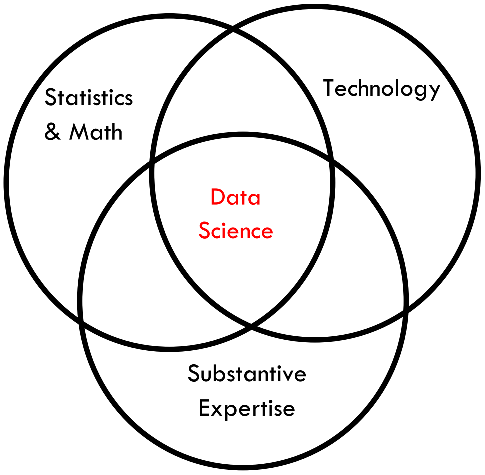
DataCamp:
https://www.datacamp.com/

What is Data Science?

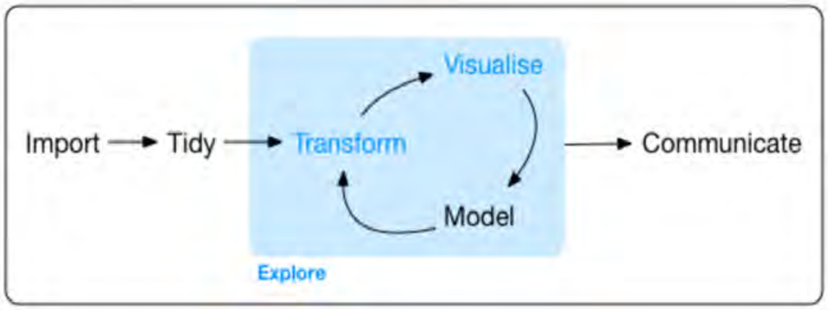
Data science is the discipline of using raw data to produce insight.

To build analytic models, we must have a strong foundation in mathematics and statistics.

To build analytic models, we must garner the power of technology.



To build analytic models, we must have a deep understanding of the phenomena at play.



Wickham & Grolemund—R for Data Science

What is R?

R is a powerful language, computing, and graphics environment. It is made up of a base software program and thousands of packages that can be added (packages written by some of the greatest statisticians and data scientists in the world). R is available for Windows and Mac, and is both open source and free.

To install R, go to http://www.r-project.org/ (click on the download R link under the getting started section). You will be prompted to choose a CRAN mirror — click on https://cloud.r-project.org/. Choose the "precompiled binary distribution" (first section) for your operating system (Windows or Mac).

If you are a Windows user, click on Download R for Windows, then click on install R for the first time, and finally click on download R for Windows. This will download a .exe file. Double click on it and follow the directions to install.

If you are a Mac user, please make sure that your operating system is up to date before you begin. Then, click on Download R for Mac OS X. Scroll down to the header Latest Release. See the note under the first paragraph that indicates you should install XQuartz. Click on this and follow the directions to download and install XQuartz. Once complete, return to the Download R for Mac OS X page. Now, click on the .pkg file listed under Latest Release. Follow the directions to download and install R.

An updated version of R comes out about once per year, with minor versions in between. It's a good idea to upgrade regularly.

What is RStudio

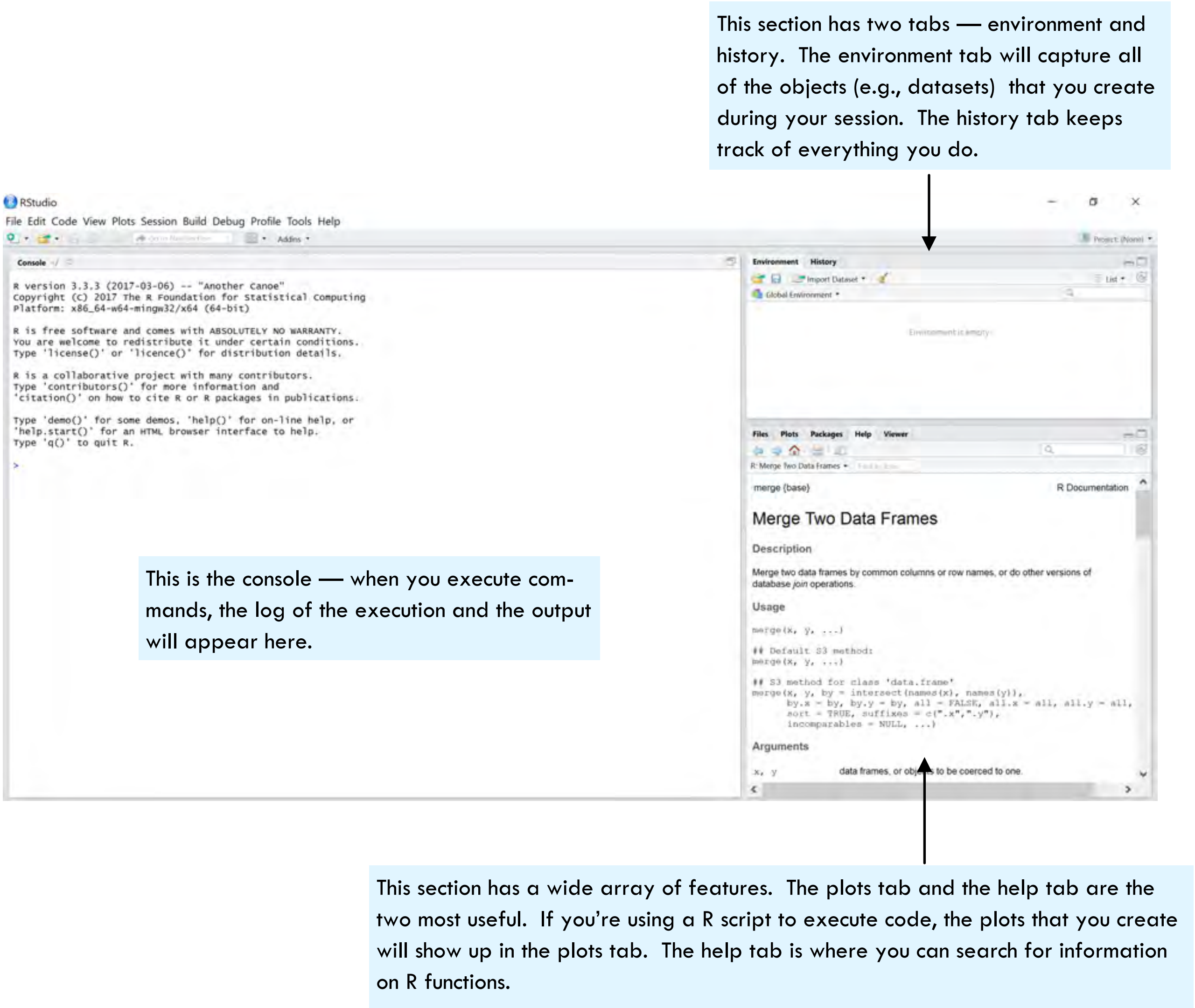
RStudio is an integrated development environment (IDE) for R. You can download it here: http://www.rstudio.com/ (click on the download now button). R Studio is also updated regularly, but R Studio will prompt you to update and it's seamless to upgrade.

Other Housekeeping Items

In order to manage and access shared files for PSY652 and PSY653, you need to create a folder to house all of these resources. First, on your hard drive (in a place where you can easily access) create a folder called RM. Prior to the start of each new unit, a Dropbox folder with the materials for the unit will be shared with you. When the folder appears in your Dropbox folder, copy the folder (e.g., Unit1), and paste it in your personal RM folder.

Let's Open RStudio

Double click on the R Studio shortcut on your desktop or choose it from the program's menu. RStudio uses R behind the scenes, so you do not need to open R.



This section has two tabs — environment and history. The environment tab will capture all of the objects (e.g., datasets) that you create during your session. The history tab keeps track of everything you do.

This is the console — when you execute commands, the log of the execution and the output will appear here.

This section has a wide array of features. The plots tab and the help tab are the two most useful. If you're using a R script to execute code, the plots that you create will show up in the plots tab. The help tab is where you can search for information on R functions.

```
R version 3.3.3 (2017-03-06) -- "Another Canoe"
Copyright (C) 2017 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

>
```

merge {base} R Documentation

Merge Two Data Frames

Description

Merge two data frames by common columns or row names, or do other versions of database *join* operations.

Usage

```
merge(x, y, ...)

## Default S3 method:
merge(x, y, ...)

## S3 method for class 'data.frame'
merge(x, y, by = intersect(names(x), names(y)),
      by.x = by, by.y = by, all = FALSE, all.x = all, all.y = all,
      sort = TRUE, suffixes = c(".x",".y"),
      incomparables = NULL, ...)
```

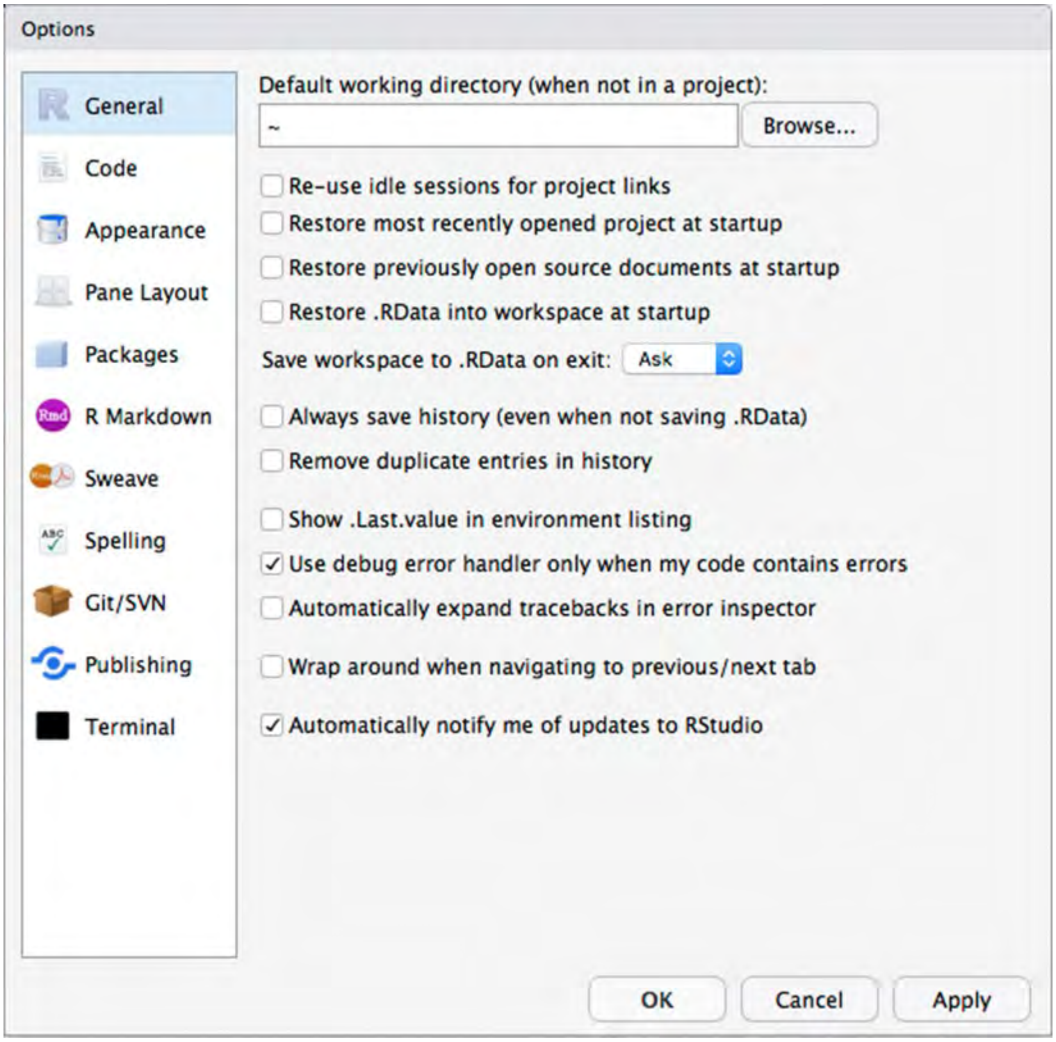
Arguments

x, y data frames, or objects to be coerced to one.

Configure R Studio

We need to configure RStudio to our liking. Here are my recommendations for configuring RStudio:

Click on TOOLS > GLOBAL OPTIONS. Then make the checked boxes and dropdown menus equivalent to those below.



Default working directory (when not in a project): ~

☐ Re-use idle sessions for project links

☐ Restore most recently opened project at startup

☐ Restore previously open source documents at startup

☐ Restore .RData into workspace at startup

Save workspace to .RData on exit: Ask

☐ Always save history (even when not saving .RData)

☐ Remove duplicate entries in history

☐ Show .Last.value in environment listing

☑ Use debug error handler only when my code contains errors

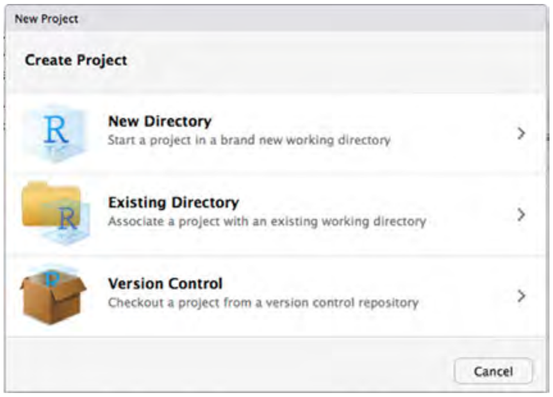
☐ Automatically expand tracebacks in error inspector

☐ Wrap around when navigating to previous/next tab

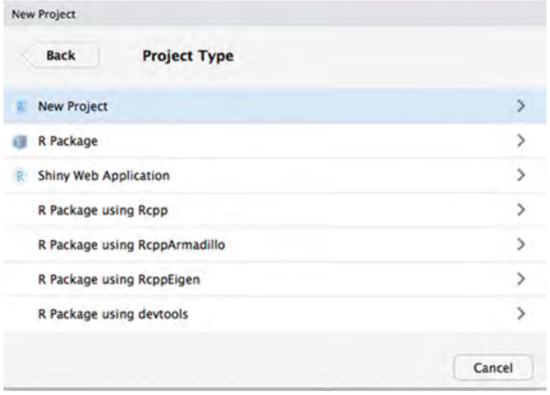
☑ Automatically notify me of updates to RStudio

Starting a New Project

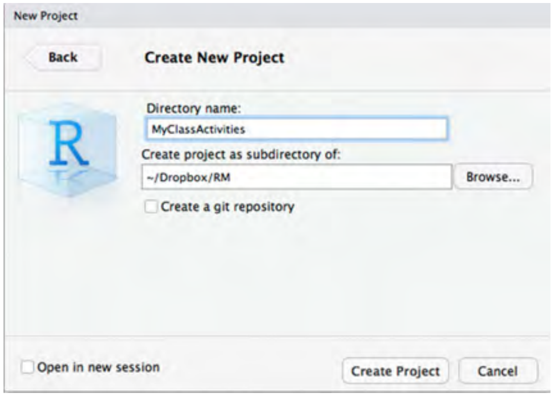
When you approach a new project, the first step is to create a project folder. To create a new project Click File > New Project, then:


New Project
Create Project
New Directory
Start a project in a brand new working directory
Existing Directory
Associate a project with an existing working directory
Version Control
Checkout a project from a version control repository
Cancel

Click New Directory



Click New Project



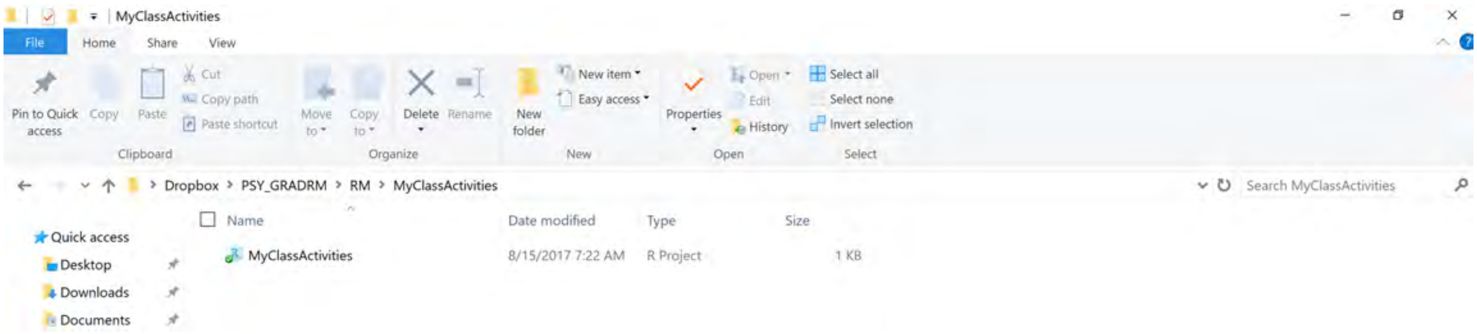
Directory name: MyClassActivities

Create project as subdirectory of: ~/Dropbox/RM

□ Create a git repository

□ Open in new session

Name the directory MyClassActivities, and indicate that it will be stored in the dropbox directory you created on the previous page. Then click "Create Project" — this will create a folder called MyClassActivities, and a R Project file of the same name. All of the files associated with this new project will be stored in this folder. When you begin working on this project, you will either open the project (FILE > OPEN PROJECT) or double click on the project file (look for Type=R Project) from the file explorer (see below).



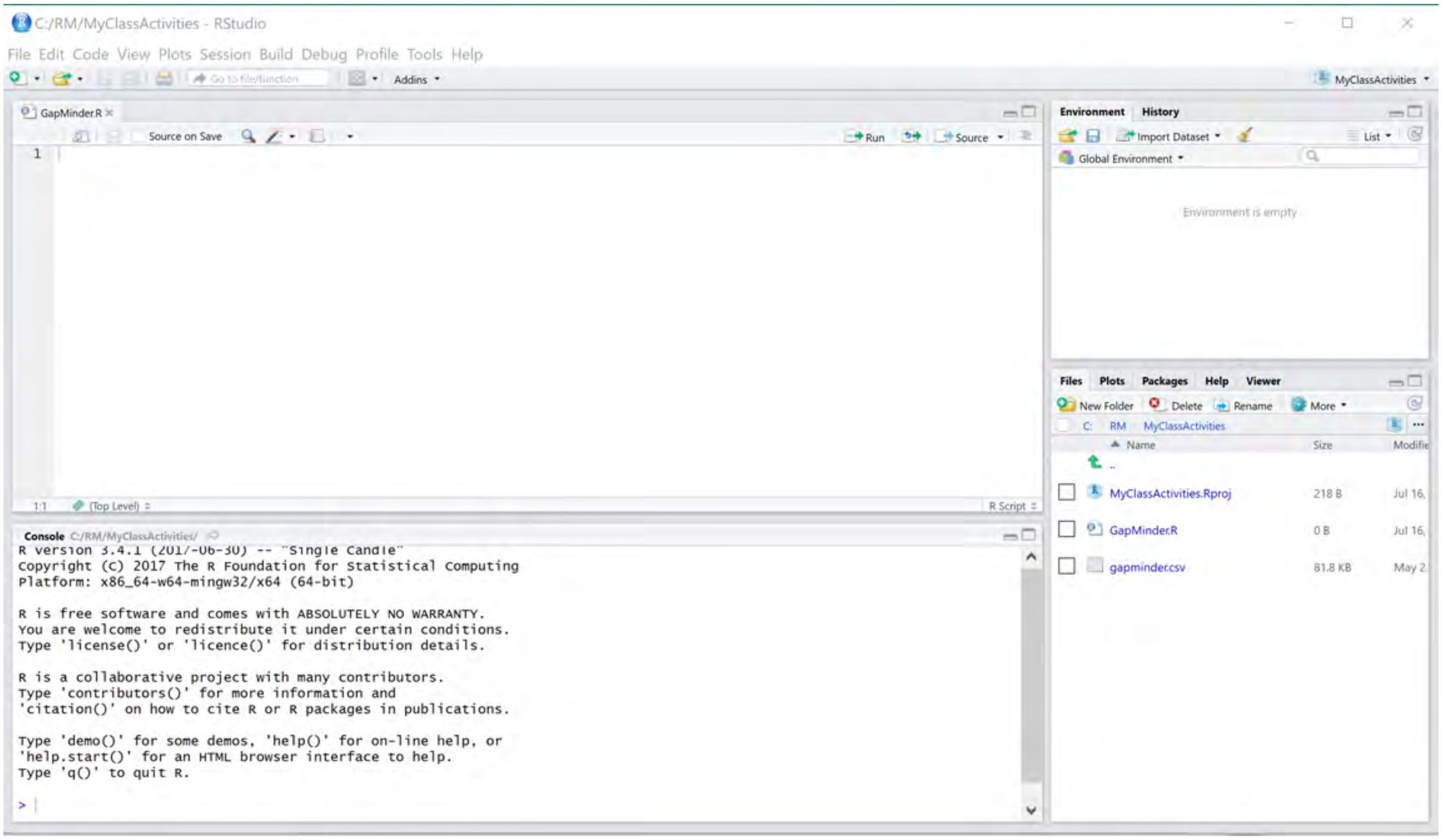
Name	Date modified	Type	Size
MyClassActivities	8/15/2017 7:22 AM	R Project	1 KB

Creating a R Script

Once a new project is created, you can begin creating files for the project. The first thing we need to do is put some data into the project folder. In the Unit1 folder that you copied over from Dropbox (and put in your RM folder) there is a csv file called gapminder.csv. Please copy that file into your MyClassActivities folder.

Now, go back to RStudio. To begin, we will use R through a R script. Click FILE > NEW FILE > R Script. This will open a new script. Let's save this script. Click on FILE > SAVE AS, and name the script GapMinder, since this will be a script that uses the gapminder dataset.

Notice that you now have an additional pane in RStudio, the R script. This is where we will type commands that will then be submitted to R for processing.



```
R version 3.4.1 (2017-06-30) -- "Single Candle"
Copyright (C) 2017 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

>
```

Name	Size	Modifie
..		
MyClassActivities.Rproj	218 B	Jul 16,
GapMinder.R	0 B	Jul 16,
gapminder.csv	81.8 KB	May 2

Notice that all of the files in our MyClassActivities project are listed in the files tab.

Add a Package

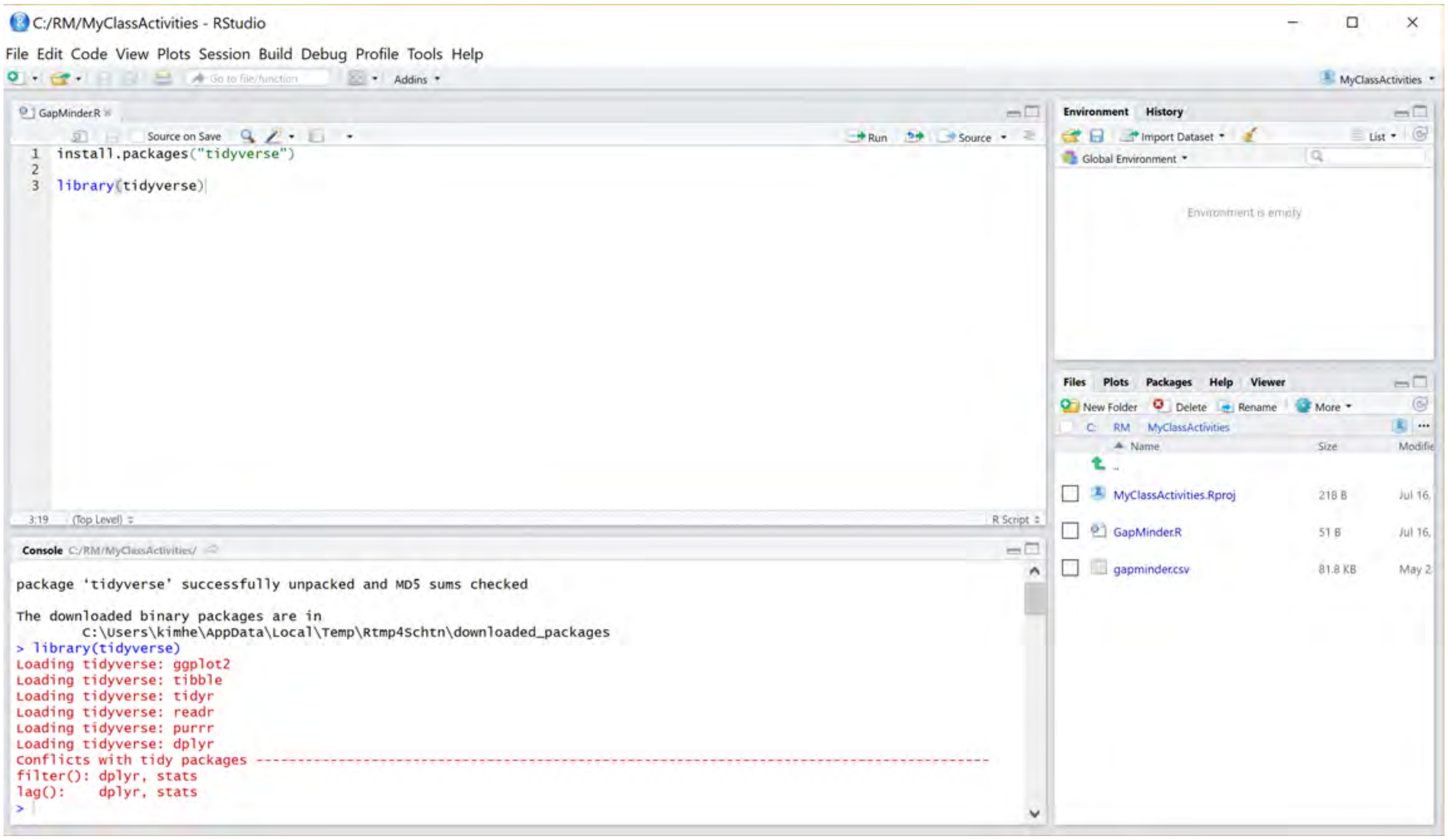
When we loaded R onto our machines we loaded base R. The true power of R is in the add on packages. These packages consist of a collection of functions that extend the capability of base R. Over the course of the semester, we will work with a variety of packages.

We will begin with a suite of packages called the tidyverse. The tidyverse is maintained by Hadley Wickham, the Chief Scientist at RStudio.

To install a package, you use the install.packages function, as follows:

install.packages(“package_name”) — where package_name is the package you desire to install. To execute code, highlight the code and then click the Run button. Once a package is installed, when you seek to use it in a R work session, you use the library function, as follows: library(package_name).

```
install.packages(“tidyverse”)
library(tidyverse)
```



```
install.packages("tidyverse")

library(tidyverse)
```

```
package ‘tidyverse’ successfully unpacked and MD5 sums checked

The downloaded binary packages are in
        C:\Users\kimhe\AppData\Local\Temp\Rtmp4Schtn\downloaded_packages
> library(tidyverse)
Loading tidyverse: ggplot2
Loading tidyverse: tibble
Loading tidyverse: tidyr
Loading tidyverse: readr
Loading tidyverse: purrr
Loading tidyverse: dplyr
Conflicts with tidy packages ----------------------------------------------------------------------------
filter(): dplyr, stats
lag():    dplyr, stats
>
```

Name	Size	Modifie
..		
MyClassActivities.Rproj	218 B	Jul 16,
GapMinder.R	51 B	Jul 16,
gapminder.csv	81.8 KB	May 2

If the package installed correctly, you will see the top message in the console — that is, that the package was successfully unpacked and checked. You only need to install a package once (although the package will need to be reinstalled when you download a new version of R and occasionally updated using update.packages(“package_name”). You can either delete the install.packages line after you install this package, or you can put a # in front of it, which R will then ignore the line of code the next time you run this script. The library command, on the other hand, will need to be executed each session for which that package will be used. This calls the package into working memory for you to use. I typically put the library command line that calls in all of the packages that I will use in a particular session at the very top of my script. R is case-sensitive!!!

Import a Dataset

To work with a dataset in R, we need to first import it. We will typically work with csv files in this course, so let's start by importing a dataset called gapminder.csv. It is the file you just copied into your new MyClassActivities folder.

The gapminder dataset is provided by an organization called Gapminder.org. It contains data on 142 countries. For each country, the dataset provides values for life expectancy, GDP per capita, and population — with these data available every five years from 1952 to 2007.

The gapminder dataset has 1704 rows and 6 variables:

- **country:** character variable with 142 levels
- **continent:** character variable with 5 levels
- **year:** numeric variable that ranges from 1952 to 2007 in increments of 5 years
- **lifeExp:** numeric variable that represents life expectancy at birth, in years
- **pop:** numeric variable that represents population
- **gdpPercap:** numeric variable that represents GDP per capita

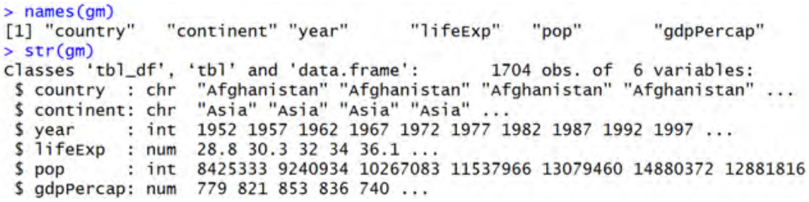
```
gm <- read_csv(file="gapminder.csv")

names(gm)
str(gm)
head(gm)
```

When you begin by creating or opening a R Project, R knows to look for the datafile in the project folder (e.g., MyClassActivities folder). Alternatively, you can specify the full path if you want to point to a different folder (e.g., C:/other_data/datafile.csv").

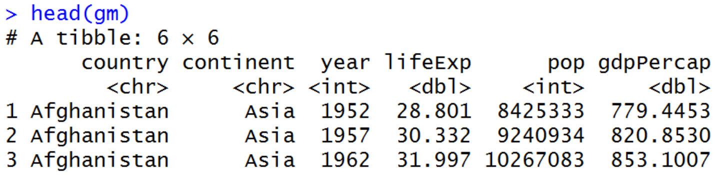
We use the read_csv function to read in the csv file. By listing gm, and then the assignment operator (<-), we are telling R to read in the gapminder csv file and name it gm. Notice that after importing this dataset, an object called gm now appears in the environment tab of RStudio, under Data. Double click on the gm dataframe in the environment tab and you can view it.

In the code above, "names", "str", and "head" are functions. The function called names will list the names of all of the variables in the dataset. The function called str will give you information about the structure of the dataset. The function called head will print out the first few rows. In the first three functions, there is only one argument included (the dataset name). As we employ more complex functions, several arguments, separated by commas, will be used. For an example of this, enhance head by changing this to:

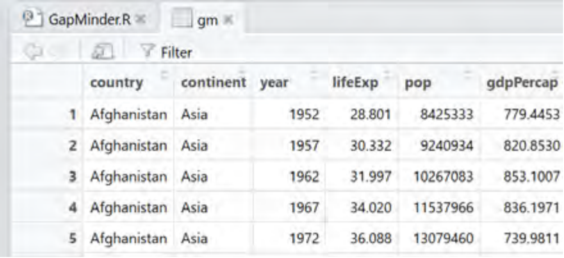
head(gm, n=10). Notice that n=10 is an additional argument which requests the top 10 rows, rather than the default 6.



```
> names(gm)
[1] "country"   "continent" "year"      "lifeExp"   "pop"       "gdpPercap"
> str(gm)
Classes 'tbl_df', 'tbl' and 'data.frame':	1704 obs. of  6 variables:
 $ country  : chr  "Afghanistan" "Afghanistan" "Afghanistan" "Afghanistan" ...
 $ continent: chr  "Asia" "Asia" "Asia" "Asia" ...
 $ year     : int  1952 1957 1962 1967 1972 1977 1982 1987 1992 1997 ...
 $ lifeExp  : num  28.8 30.3 32 34 36.1 ...
 $ pop      : int  8425333 9240934 10267083 11537966 13079460 14880372 12881816
 $ gdpPercap: num  779 821 853 836 740 ...
```



```
> head(gm)
# A tibble: 6 × 6
      country continent  year lifeExp      pop gdpPercap
        <chr>     <chr> <int>   <dbl>    <int>     <dbl>
1 Afghanistan      Asia  1952  28.801  8425333  779.4453
2 Afghanistan      Asia  1957  30.332  9240934  820.8530
3 Afghanistan      Asia  1962  31.997 10267083  853.1007
```



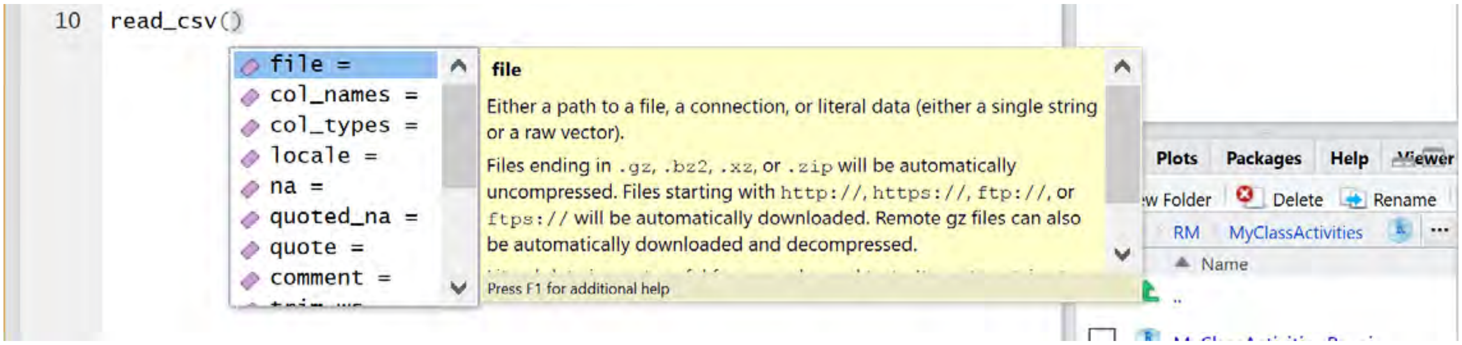
	country	continent	year	lifeExp	pop	gdpPercap
1	Afghanistan	Asia	1952	28.801	8425333	779.4453
2	Afghanistan	Asia	1957	30.332	9240934	820.8530
3	Afghanistan	Asia	1962	31.997	10267083	853.1007
4	Afghanistan	Asia	1967	34.020	11537966	836.1971
5	Afghanistan	Asia	1972	36.088	13079460	739.9811

*You will see R refer to real numbers as doubles (dbl). R will call text variables chr for character, and numerical variables without decimal places int for integer.

A Bit on Functions

We just used a series of functions, for example, read_csv, names, str, etc. R is made up of millions of functions. A function is piece of code written to carry out a set of directions. A function (e.g., read_csv) will be followed by round brackets (i.e., parentheses) — inside the round brackets you can specify the arguments (i.e., options) of the function. In R studio, you can see the arguments of the function and get some help by typing the name of the function, the first round bracket and then hit tab (see first screen shot). You can also use the help tab in the lower right pane of RStudio to search for a function. Over the course of the semester, we will work with many functions and explore the most useful arguments that are possible for each.

You can see the code that makes up the function by typing the name of the function, highlight it, and click Run (see second screen shot). This will print out the code that makes up the function in the console.



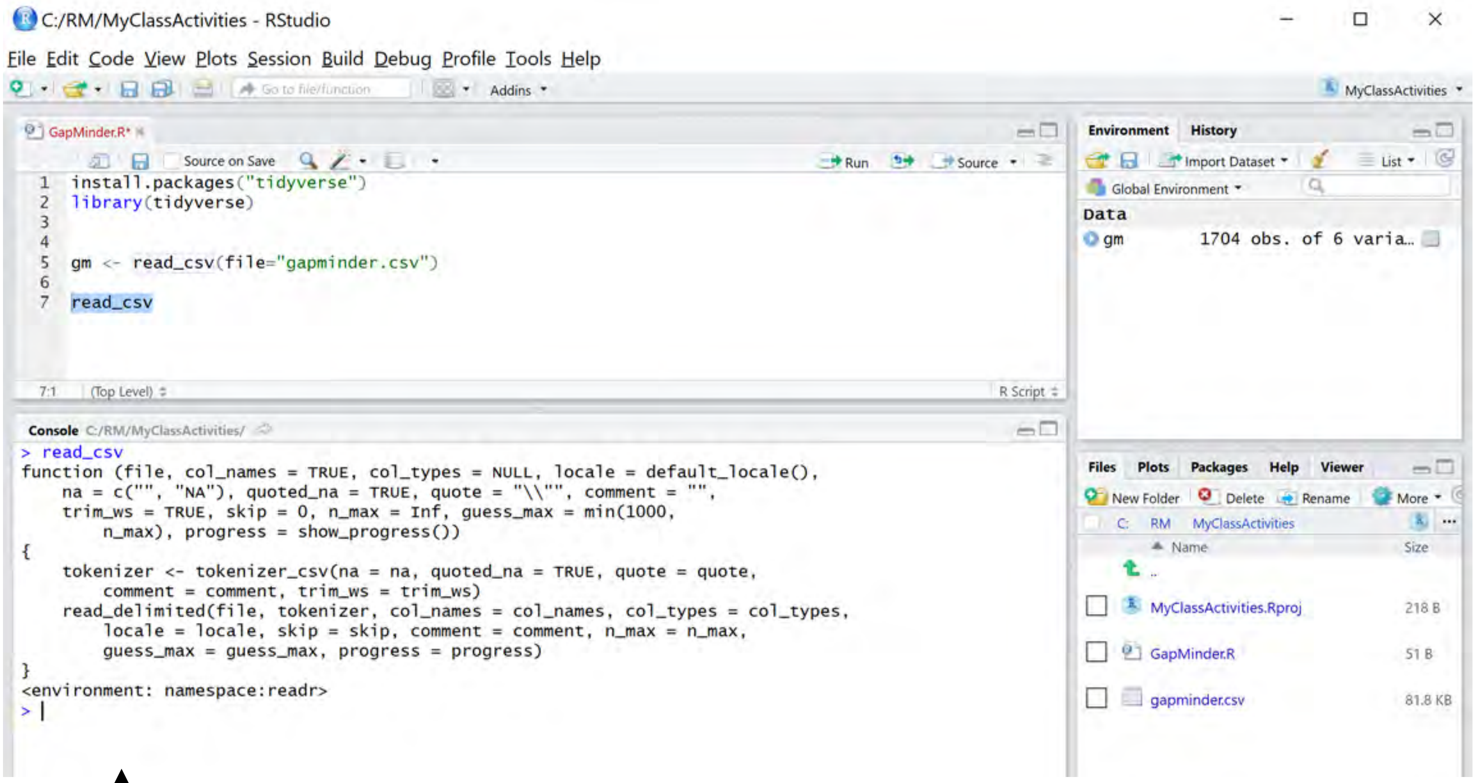
```
read_csv()
```

file

Either a path to a file, a connection, or literal data (either a single string or a raw vector).

Files ending in `.gz`, `.bz2`, `.xz`, or `.zip` will be automatically uncompressed. Files starting with `http://`, `https://`, `ftp://`, or `ftps://` will be automatically downloaded. Remote gz files can also be automatically downloaded and decompressed.

Press F1 for additional help



```
install.packages("tidyverse")
library(tidyverse)


gm <- read_csv(file="gapminder.csv")

read_csv
```

Data

gm	1704 obs. of 6 varia…

Name	Size
..	
MyClassActivities.Rproj	218 B
GapMinder.R	51 B
gapminder.csv	81.8 KB

```
> read_csv
function (file, col_names = TRUE, col_types = NULL, locale = default_locale(),
    na = c("", "NA"), quoted_na = TRUE, quote = "\"", comment = "",
    trim_ws = TRUE, skip = 0, n_max = Inf, guess_max = min(1000,
        n_max), progress = show_progress())
{
    tokenizer <- tokenizer_csv(na = na, quoted_na = TRUE, quote = quote,
        comment = comment, trim_ws = trim_ws)
    read_delimited(file, tokenizer, col_names = col_names, col_types = col_types,
        locale = locale, skip = skip, comment = comment, n_max = n_max,
        guess_max = guess_max, progress = progress)
}
<environment: namespace:readr>
> |
```

↑

Note that you will likely want to regularly clear the console. To do this, click EDIT > CLEAR CONSOLE

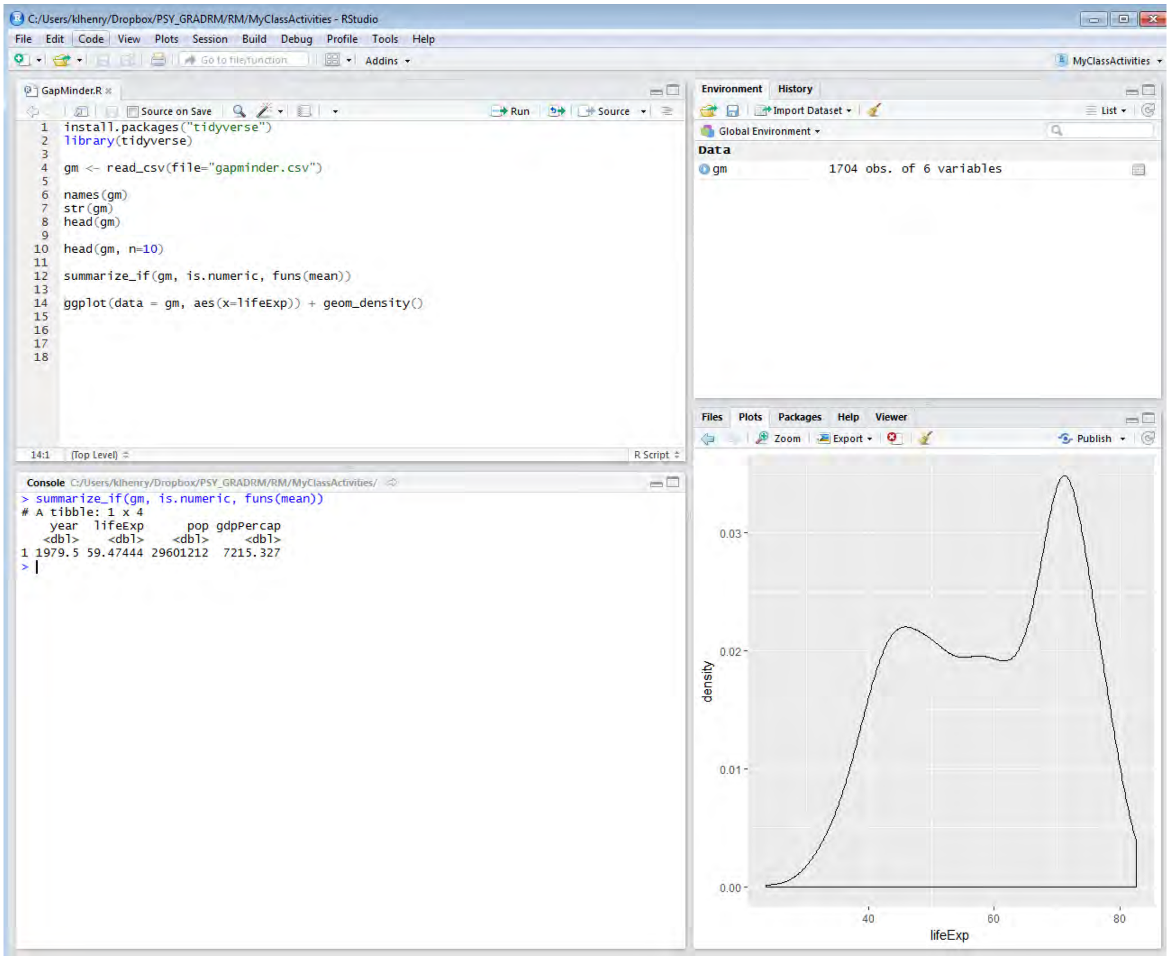
Let’s Submit Code to R

Over the coming weeks, we will work up to learning how to understand and write code, but for now, we’ll just take a look at how code is submitted. First, let’s get the mean of all of the numeric data in the gapminder dataframe.

```
summarize_if(gm, is.numeric, list(mean))
```

Second, let’s create a simple plot to present the distribution of life expectancy.

```
ggplot(data = gm, aes(x=lifeExp)) + geom_density()
```



```
install.packages("tidyverse")
library(tidyverse)

gm <- read_csv(file="gapminder.csv")

names(gm)
str(gm)
head(gm)

head(gm, n=10)

summarize_if(gm, is.numeric, funs(mean))

ggplot(data = gm, aes(x=lifeExp)) + geom_density()
```

```
Data
gm          1704 obs. of 6 variables
```

```
> summarize_if(gm, is.numeric, funs(mean))
# A tibble: 1 x 4
    year  lifeExp      pop gdpPercap
   <dbl>    <dbl>    <dbl>     <dbl>
1 1979.5 59.47444 29601212  7215.327
> |
```

The results from the first line of code print out in the console, we see the mean of each of the numeric variables in the dataframe.

The results of the second line produce a plot, and the plot is displayed in the plot window of the lower right pane of RStudio.

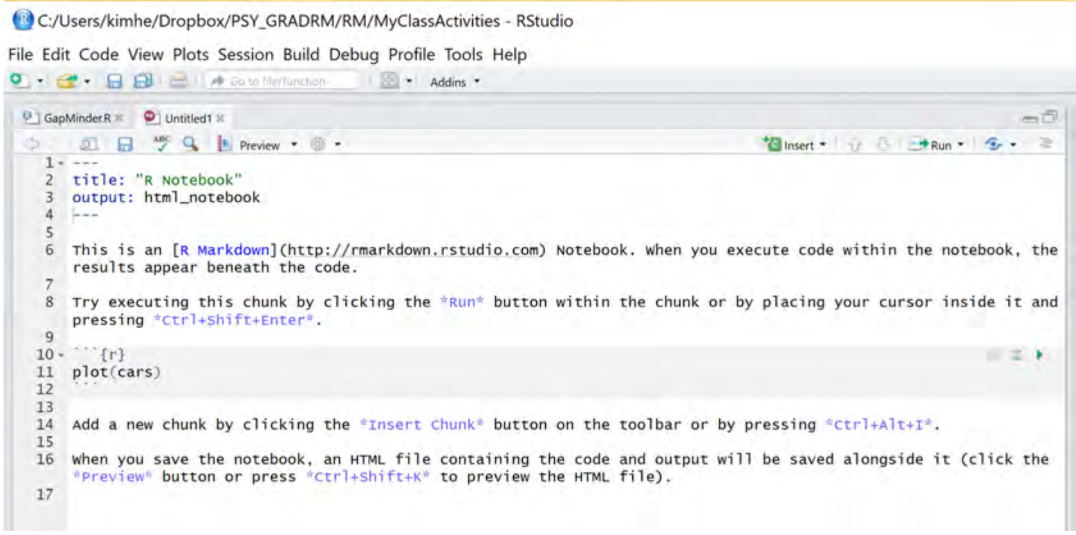
Now that we are done, let’s save the R script. Notice that the name will change from RED to BLACK, indicating that all edits to the file have been saved. At this time, it is safe to exit. Please exit out of RStudio.

R Notebooks

We just worked with R via a R script. In 2016, RStudio released a new way of managing analysis projects called R Notebooks. It's a great way of integrating R syntax and output, and creating slick and reproducible reports. This is the primary way in which we will interact with R in this course.

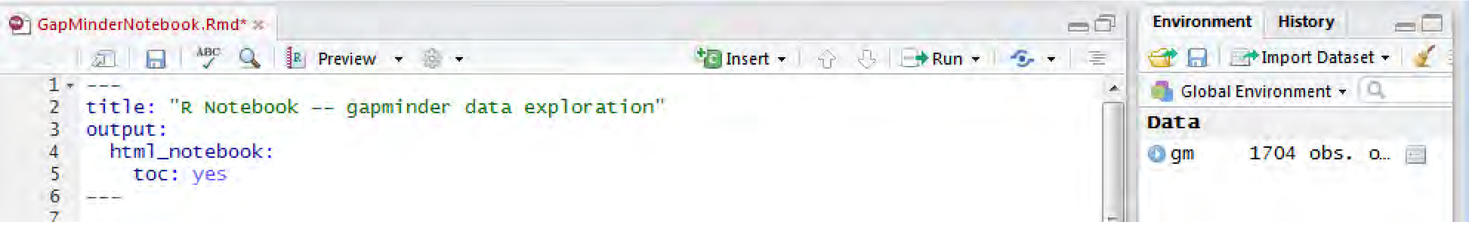
To begin, open your R project created earlier — FILE > OPEN PROJECT, and navigate to your MyClassActivities project. Now, start a R Notebook, click FILE > NEW FILE > R NOTEBOOK.

When you open up a new R NOTEBOOK, it contains some pre-created components to help get you started.


C:/Users/kimhe/Dropbox/PSY_GRADRM/RM/MyClassActivities - RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
GapMinder.R
Untitled1
Preview
Insert
Run

~~~
---
title: "R Notebook"
output: html_notebook
---

This is an [R Markdown](http://rmarkdown.rstudio.com) Notebook. When you execute code within the notebook, the results appear beneath the code.

Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing *Ctrl+Shift+Enter*.

```{r}
plot(cars)
```

Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by pressing *Ctrl+Alt+I*.

When you save the notebook, an HTML file containing the code and output will be saved alongside it (click the *Preview* button or press *Ctrl+Shift+K* to preview the HTML file).
~~~

Let's begin to modify this. First, click on the gear icon, then click OUTPUT OPTIONS. On the first tab, you can request a table of contents (TOC). Next, add a more informative title (R Notebook -- gapminder data exploration). Save the notebook as GapminderNotebook in your current project folder. Note that it is best to not include spaces in the names of any files you use (e.g., script names, notebook names, datafile names).



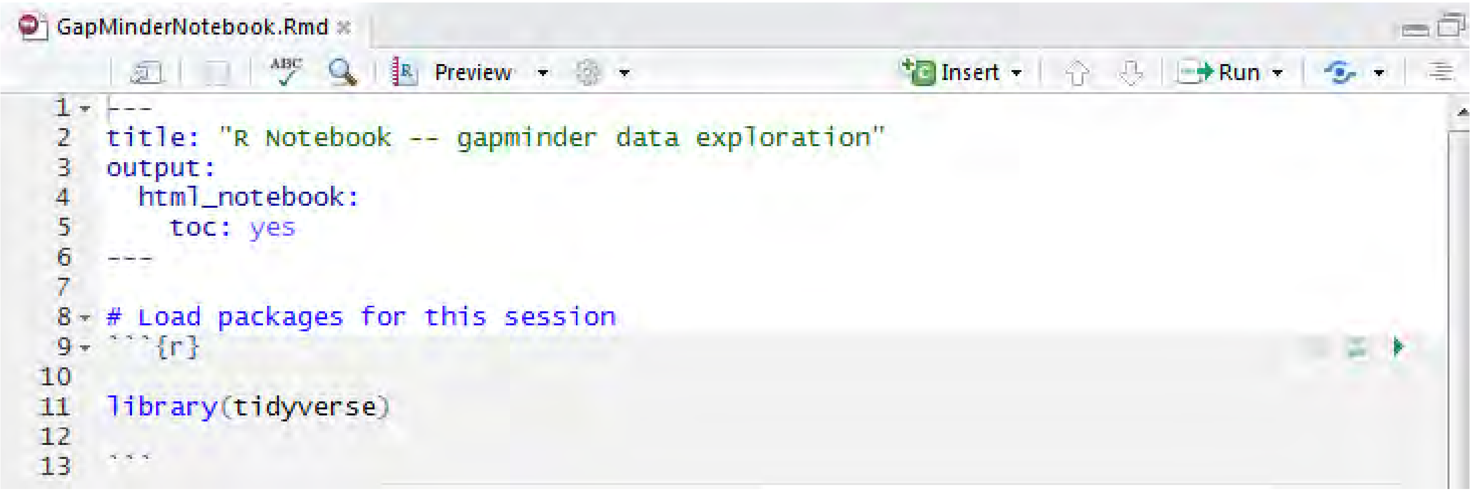
```
---
title: "R Notebook -- gapminder data exploration"
output:
  html_notebook:
    toc: yes
---
```

gm 1704 obs. o...

R Notebooks — Load the tidyverse package

The gray part just below this section label is called a R code chunk. Think of this as a mini R script. In this first code chunk, we will load the libraries needed. Let's call this code chunk "Load packages for this session." Note that the hashtag outside of a code chunk has a special role — it will allow us to build our TOC. One # is the first level header, two # (##) is a second level header, etc.

Now, let's load tidyverse using the library statement. Click the green arrow on the upper right side of the code chunk. This will run the contents of the code chunk.

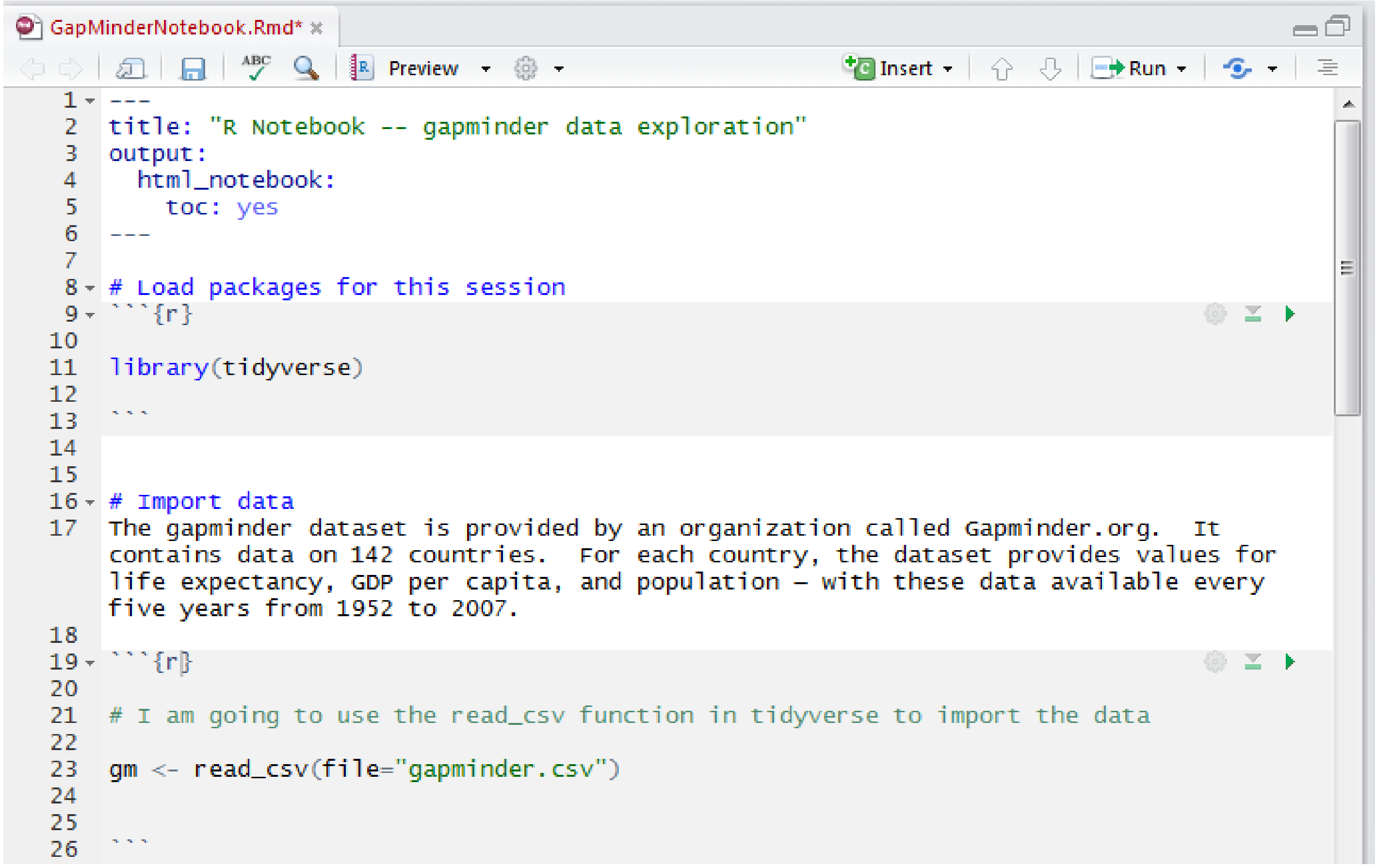


~~~
---
title: "R Notebook -- gapminder data exploration"
output:
  html_notebook:
    toc: yes
---

# Load packages for this session
```{r}

library(tidyverse)

```
~~~

R Notebooks — Import Data

Now, let's add another R code chunk to import the data. First, click INSERT (at top of pane) > R. This will make a new code chunk. Let's name this code chunk "Import data" - remember to put a # in front so R knows it's a first level header and will populate in our TOC.

Note that text not placed after a hashtag outside of a code chunk is a good place to describe what you're doing, provide more information to the reader, interpret results, etc. As was the case in the regular R script, if you want to make notes **inside** a code chunk, then always use the hashtag.



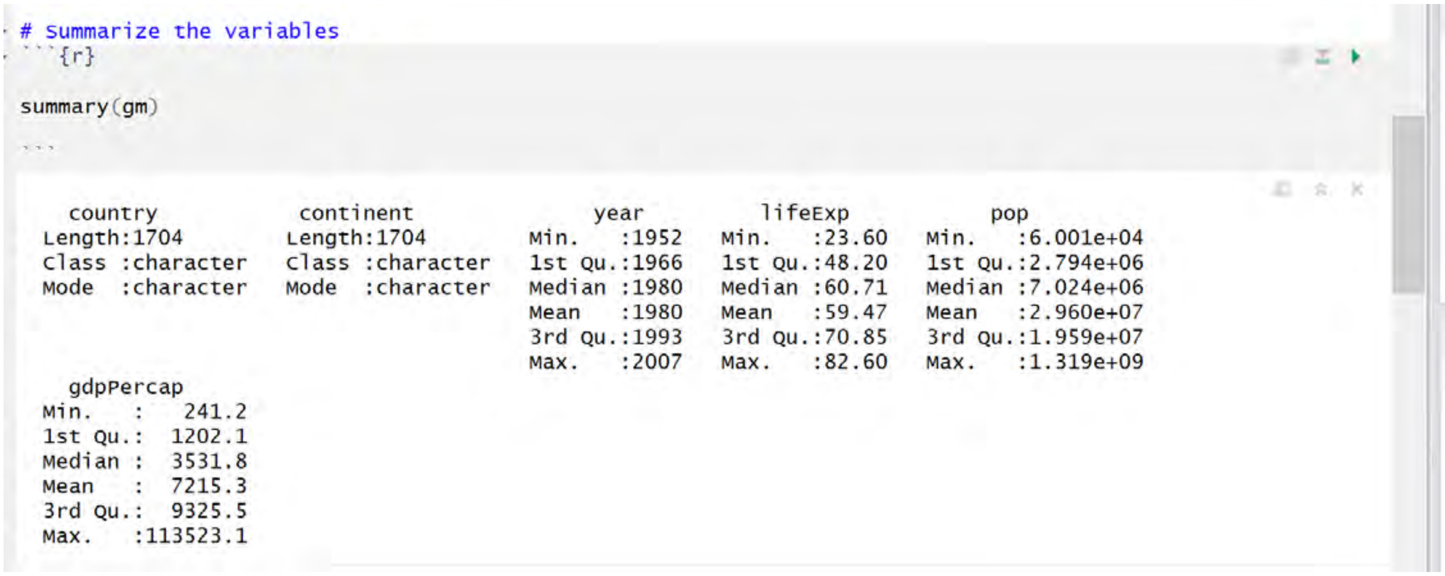
~~~
---
title: "R Notebook -- gapminder data exploration"
output:
  html_notebook:
    toc: yes
---

# Load packages for this session
```{r}

library(tidyverse)

~~~

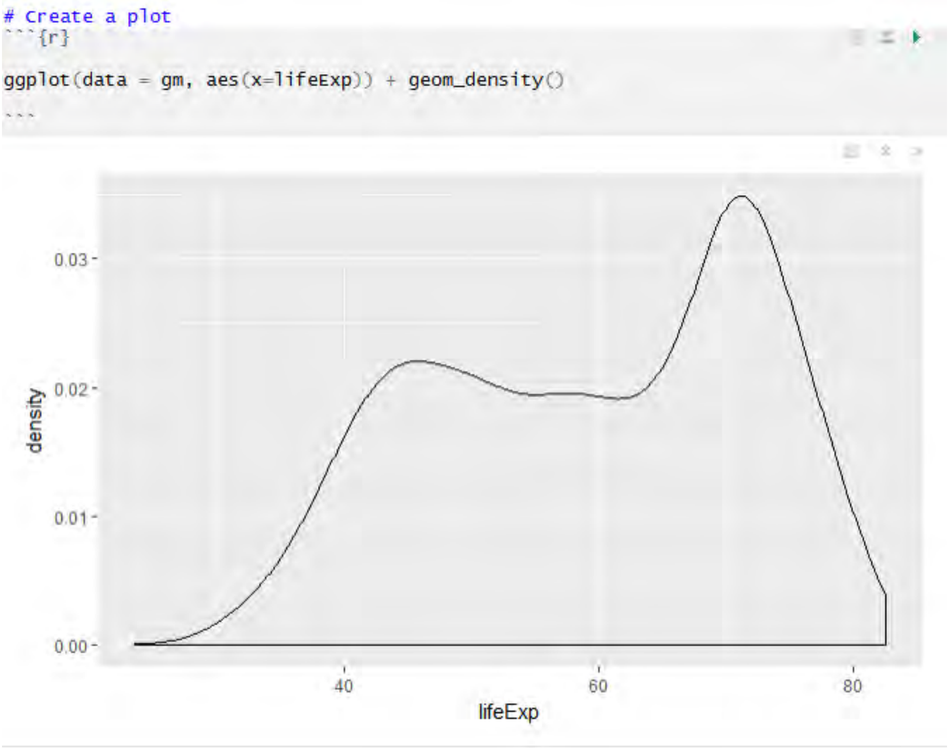
Import data
The gapminder dataset is provided by an organization called Gapminder.org. It contains data on 142 countries. For each country, the dataset provides values for life expectancy, GDP per capita, and population – with these data available every five years from 1952 to 2007.

```{r}

# I am going to use the read_csv function in tidyverse to import the data

gm <- read_csv(file="gapminder.csv")


```
```
```

R Notebooks — Create Output

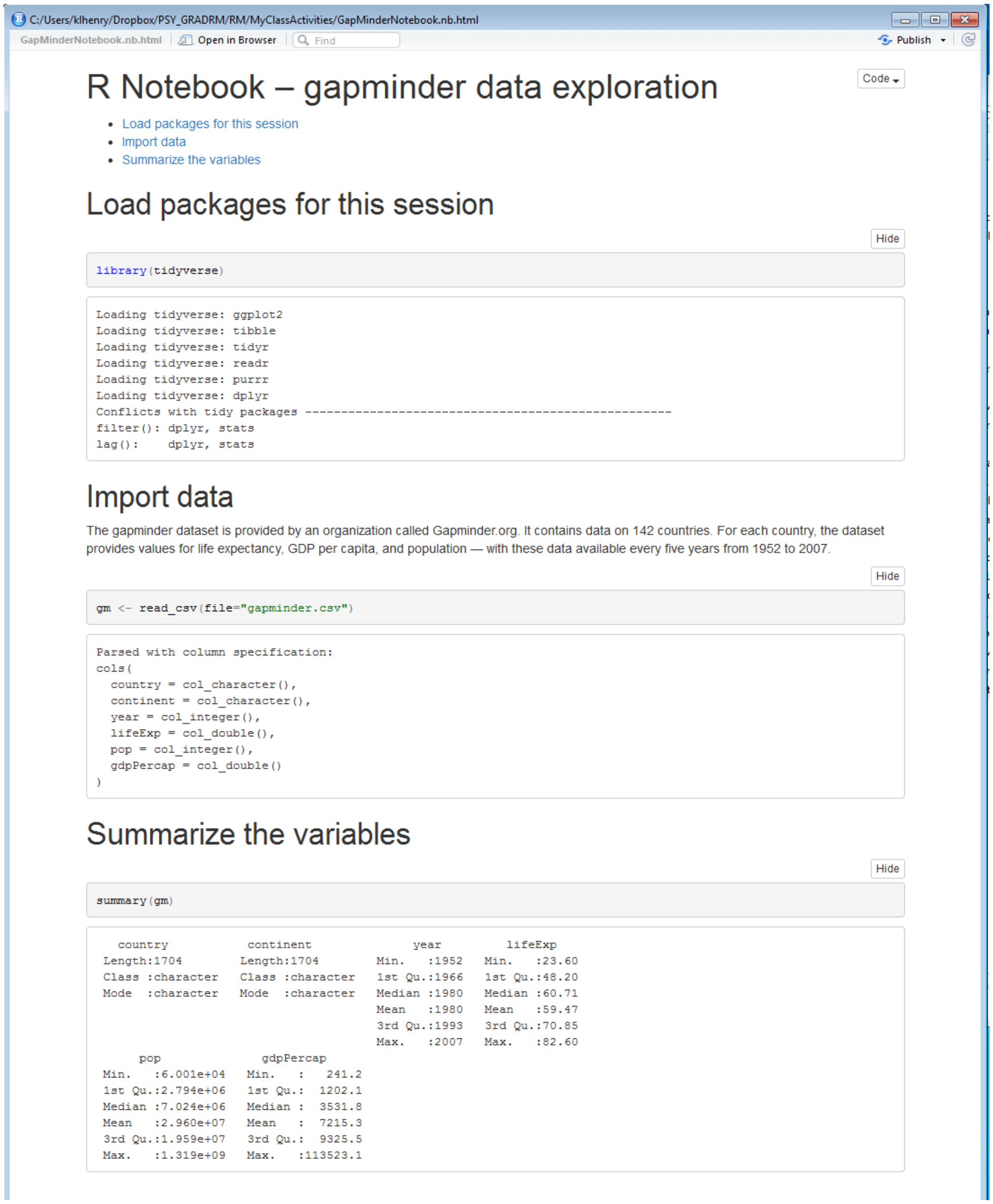
Now, let's add another R code chunk to get some basic descriptive statistics. First, click INSERT (at top of pane) > R. Let's name this code chunk "Summarize the variables" - remember to put a # in front so R knows it's a first level header and will populate in our TOC. Inside the code chunk, let's ask for a summary of the variables in the dataframe. We do this with the summary function. Once complete, click the green arrow to execute the code chunk.



~~~
# Summarize the variables
```{r}

summary(gm)

~~~
```

```
   country            continent              year         lifeExp           pop
 Length:1704        Length:1704        Min.   :1952   Min.   :23.60   Min.   :6.001e+04
 Class :character   Class :character   1st Qu.:1966   1st Qu.:48.20   1st Qu.:2.794e+06
 Mode  :character   Mode  :character   Median :1980   Median :60.71   Median :7.024e+06
                                       Mean   :1980   Mean   :59.47   Mean   :2.960e+07
                                       3rd Qu.:1993   3rd Qu.:70.85   3rd Qu.:1.959e+07
                                       Max.   :2007   Max.   :82.60   Max.   :1.319e+09
   gdpPercap
 Min.   :   241.2
 1st Qu.:  1202.1
 Median :  3531.8
 Mean   :  7215.3
 3rd Qu.:  9325.5
 Max.   :113523.1
```

Let's add one more code chunk to create a simple plot. Again, click INSERT > R. Label the code chunk as below and type the commands to create a density plot of one of the variables in the dataframe.



```
# Create a plot
```{r}
ggplot(data = gm, aes(x=lifeExp)) + geom_density()
```
```
```

Create the Full Notebook

Now that we have all of the analyses complete, let's restart R and run the entire file. Do this by clicking RUN > RESTART R AND RUN ALL CHUNKS. This is going to restart R and run your entire sequence from top to bottom. This is an important step because we want to ensure all code is in the correct sequence and executes without error. This is what helps to ensure your code is REPRODUCIBLE. Once you verify that everything is in order, click PREVIEW > PREVIEW NOTEBOOK. This will cause a pop up file of your notebook to appear. The notebook output is also automatically saved in your project folder. It will have the same name as your notebook input file, but with a .nb extension.


C:/Users/klhenry/Dropbox/PSY_GRADRM/RM/MyClassActivities/GapMinderNotebook.nb.html
GapMinderNotebook.nb.html
Open in Browser
Find
Publish
Code
Hide
Hide
Hide

R Notebook – gapminder data exploration

- Load packages for this session
- Import data
- Summarize the variables

Load packages for this session

```
library(tidyverse)
```

```
Loading tidyverse: ggplot2
Loading tidyverse: tibble
Loading tidyverse: tidyr
Loading tidyverse: readr
Loading tidyverse: purrr
Loading tidyverse: dplyr
Conflicts with tidy packages ---------------------------------------------------
filter(): dplyr, stats
lag():    dplyr, stats
```

Import data

The gapminder dataset is provided by an organization called Gapminder.org. It contains data on 142 countries. For each country, the dataset provides values for life expectancy, GDP per capita, and population — with these data available every five years from 1952 to 2007.

```
gm <- read_csv(file="gapminder.csv")
```

```
Parsed with column specification:
cols(
  country = col_character(),
  continent = col_character(),
  year = col_integer(),
  lifeExp = col_double(),
  pop = col_integer(),
  gdpPercap = col_double()
)
```

Summarize the variables

```
summary(gm)
```

```
   country           continent              year         lifeExp     
 Length:1704        Length:1704        Min.   :1952   Min.   :23.60  
 Class :character   Class :character   1st Qu.:1966   1st Qu.:48.20  
 Mode  :character   Mode  :character   Median :1980   Median :60.71  
                                       Mean   :1980   Mean   :59.47  
                                       3rd Qu.:1993   3rd Qu.:70.85  
                                       Max.   :2007   Max.   :82.60  
      pop              gdpPercap       
 Min.   :6.001e+04   Min.   :   241.2  
 1st Qu.:2.794e+06   1st Qu.:  1202.1  
 Median :7.024e+06   Median :  3531.8  
 Mean   :2.960e+07   Mean   :  7215.3  
 3rd Qu.:1.959e+07   3rd Qu.:  9325.5  
 Max.   :1.319e+09   Max.   :113523.1  
```

Let's end the session by saving the Notebook file, and then close RStudio.

Tips for R Notebooks

1. Think carefully about headings and subheadings and use the hashtags to populate the table of contents. As your notebook grows, the table of contents will become very important in helping you to find sections of your report.
2. Underneath headings (but not in the code chunk), you can have text to describe why you did something or interpret results.
3. Try to make each code chunk create only one piece of output, this makes reading the outputted notebook easier.
4. Before finalizing the report, always "Restart R and Run All Code Chunks"